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XXIII.—*Remarks on the Structure of the Hand in Pipa and Xenopus.* By DR. HECTOR F. E. JUNGENSEN, of Copenhagen.

IN examining the hands of the two above-named Batrachians, it will soon be obvious that the distinctly pronounced difference between the dorsal and volar sides met with in other Anurans is here obliterated; in both genera the tubercles and warts usually characterizing the volar surface are absent. This fact, together with the great similarity of the fingers, renders it difficult to understand the hand correctly, as at first sight the inner fingers are undistinguishable from the outer, and it is not clear which is the upper and which the lower side. From the following it will appear that hitherto all observers of *Pipa* and most observers of *Xenopus* have been misled and have misinterpreted the hand in these animals in one or both respects.

As is well known, the hand in all Anurans has four fingers (II-V), the two innermost of which (II and III) in nearly all the Phaneroglossa are provided with two phalanges, the two outer with three* ; also in Aglossa

* Exception were first pointed out by Peters (Reise nach Mossambique, iii. 1882), and lately Boulenger ("Note on the Classification of the Ranidae," *Ann. & Mag. N. Hist. Ser. 6. Vol. viii.* 13

(*Pipa* and *Xenopus*) we find two neighbouring fingers with two phalanges, the two others with three, a fact easily seen on bending the fingers in any specimen preserved in spirit: but whether the two-articulated fingers really are the inner ones as in *Phaneroglossa* may seem open to doubt if the examination is confined to the exterior alone; closer examination of the skeleton will, however, soon dispel any doubt.

PIPA.

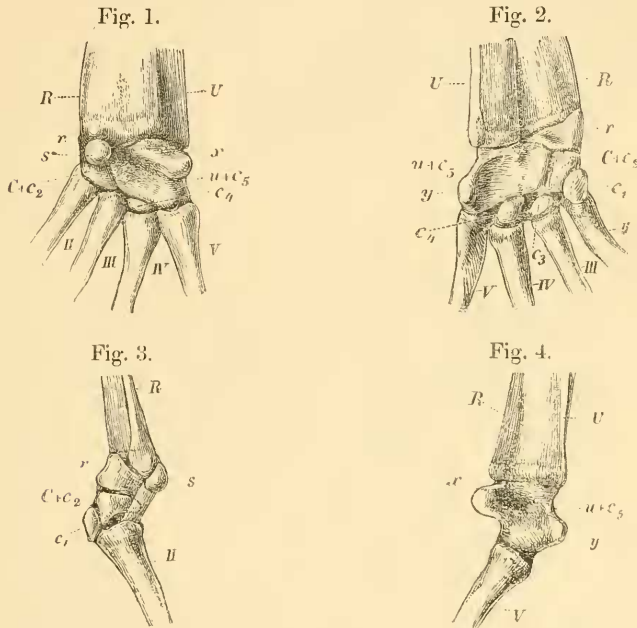
The coalescence of the bones of the forearm in this genus is more complete than in other Anurans, but still the position of radius and ulna is easily distinguished, and so it will be seen that the three-articulated fingers really belong to the ulnar side. The lower end of the radius is broader than the corresponding end of the ulna, and provided with an expansion of the inner edge; the whole forearm is strongly compressed, with sharp ulnar and radial edges, its lower end being strongly concave behind and rather convex in front.

The *carpus* has all its constituents ossified, but the interspaces between some of the pieces are filled with connective tissue. In the proximal series it contains two bones of very different size. The ulnar (figs. 1, 2, and 4, $u+c_5$) is by far the greater of all the carpal bones: proximally it carries a large articular surface for the ulna and also another smaller, but still considerable, for a part of the radius; distally it is provided on the outer side with a rounded head for the metacarpale V, and consequently it extends through the whole carpus; towards its inner (medial) side are two converging articular faces—one superior, smaller, for the radial piece, the other inferior, larger, for the carpal bone ($C+c_2$). The fore side is concave, but rises towards the outer edge, nearly opposite to the groove that separates the ulna and the radius, into a large process (x), in which some of the muscles of the arm are inserted, and muscles for the dorsal flexion of the fingers take their origin; on the hinder face the bone in question is also concave, and is here, under the sharp edge of the ulna, provided with a heel-shaped process (y), smaller and in a

Proc. Zool. Soc. 1888, p. 204) has shown that the genera *Cassina*, Gir., *Hylambates*, A. Dum., *Rappia*, Gthr., *Megalicalus*, Gthr., *Ithacophorus*, Kuhl, *Chiromantis*, Peters, *Lvalus*, Tsch., and *Nyctivalus*, Bouleng., have a small bone intercalated between the outermost phalange and that which otherwise is the penultimate, so that the fingers are provided with 3, 3, 4, 4 (and the toes with 3, 3, 4, 5, 4) phalanges.

lower position than that of the fore side; a glance at fig. 4 will make this plainer than any description could.

The radial bone of the carpus is considerably smaller, irregularly wedge-shaped, on the fore side somewhat convex, on the hind face concave, and has on the upper side an oval articular facet for the inner (medial) part of the radius, and



Left hand of *Pipa*. Fig. 1 seen from the dorsal side; fig. 2 from the volar side; fig. 3 from the radial, fig. 4 from the ulnar side.

R, radius; U, ulna; r, radiale; u+c₅, the coalesced ulnare and carpal 5; C+c₂, the coalesced centrale and carpal 2; c₁, c₃, c₄, carpalia 1, 3, and 4; s, sesamoid bone; II-V, metacarpalia II-V. In fig. 3 the ligament between the sesamoid and metacarpale V is seen.

projects in a free point behind the latter bone (*cf.* figs. 2 and 3); distally it is provided with a large facet, articulating partly with the great ulnar bone, partly with the underlying carpal bone of the lower series, C+c₂; when seen from in front the radial carpal bone is nearly hidden by a rounded little bone (s), resembling a small patella, which lies just before the junction of the two proximal pieces and undoubtedly represents a sesamoid bone.

In examining the distal series of the carpus from the dorsal side only two pieces are seen, viz. a small oval carpal bone

(c_4), which carries the fourth metacarpal and above joins the great ulnar bone, and a larger radial carpale, $C+c_2$, which carries metacarpale II, and by means of a very little facet partly also metacarpale III; but if the carpus is seen from behind (fig. 2) the distal series presents four pieces (in addition to the lower part of the great ulnar bone), which, counting from the ulnar side, are: carpale 4, which seen from this side is larger and projects somewhat heel-shaped and joins a small, rounded carpale 3, not visible from the dorsal side; the bone $C+c_2$; and finally, articulated with the latter and distally also with the metacarpale II, a still smaller oval bone, which, in spite of its looking like a sesamoid, I regard as a true carpal bone (c_1). Thus the whole carpus of *Pipa* consists of 6, or, if we include the sesamoid bone (s), of 7 discrete bony pieces.

If we compare the statements of previous authors with the above, rather considerable differences are met with.

In the osteology of *Pipa*, prefixed as an explanation of the plates to the first volume of the well-known work of F. G. Schneider*, we find the following description:—“*Ossa carpi 7, unum maximum polygonum in latere interiore* cujus ad latus *externum* duo minora, sed tertium *inferius* magis adhæret. In secunda serie quatuor minora, quorum maximum versus *exteriora*.” Thus the number is correct, but, as is shown by the words in italics, Schneider has mistaken the outer for the inner side and *vice versâ*, and confounded the volar and dorsal faces. When these facts are remembered, the other statements will be recognized as quite true (*cf.* my figures); Schneider’s own figure (*l. c.* tab. ii fig. 3) is poor and does not agree with the text, presenting only one carpal, the ulnar “maximum polygonum.”

F. W. Breyer † adds nothing of his own to our knowledge of the carpus; but his two plates show that he shares in the views of Schneider, the hand in both being turned round, *i. e.* with the underside upwards, while the arm is in the right position, as also is the process x of the great ulnar carpale (at m on tab. i., at n on tab. ii.), which is distinctly given, while the other carpal bones are indistinctly and rather incorrectly represented.

F. T. Meckel ‡ says:—“Bei der *Pipa* . . . finden sich nur sechs, in zwei Reihen stehende Knochen. Die erste

* ‘*Historia Amphibiorum naturalis et literaria*,’ Jena, 1799, 1 Bd. Tabularum ære expressarum interpretatio, p. 262.

† ‘*Observationes anatomicæ circa fabricam Ranæ Pipæ*,’ Berl. 1811 (the dissertation is “*præsidiæ Rudolphi*,” and thus it is often regarded as a paper of the latter author).

‡ ‘*System der vergleichenden Anatomie*,’ 2 Th.. 1 Abth., 1824, p. 459.

enthält zwei. Der *vordere* ist der bei weitem grösste, breit, kurz, und scheint aus dem ersten und zweiten des ersten und dem ersten der zweiten Reihe bei den übrigen ungeschwänzten Batrachiern verwachsen zu sein, indem es den Mittelhandknochen des *ersten* Fingers trägt. Von den vier Knochen der zweiten Reihe ist der *vorletzte* der grösste, der *vierte* * liegt ausser der Reihe, der *erste*, *zweite* und *dritte* tragen den *zweiten*, *dritten* und *vierten* Mittelhandknochen." The number 6 is thus obtained by Meckel in leaving out of consideration the little bone, which I regard as a sesamoid (*s*); the italic words in his description show that he falls into the same error as Schneider.

C. Mayer † describes the carpus as follows:—"In einer hinteren Reihe 1. das sehr grosse *os naviculare* ‡, welches alle übrigen *ossa carpi* zusammengenommen an Masse übertrifft. Es steht rückwärts mit dem vereinten Knochen des Vorderarms und vorwärts mit dem *os metacarpi* des *ersten* Fingers, mit dem *os capitatum* § und *os hamatum* || in Verbindung. 2. Das *os lunatum* ¶ steht mit dem *os antibrachii*, mit dem *os naviculare* und *pisiforme* **, nach vorwärts mit dem *os hamatum* in Verbindung. 3. Ein *os pisiforme*, mit dem *os lunatum* articulirend. In der vorderen Reihe: 4. das *os hamatum*. Es steht in Verbindung nach vorwärts mit den *ossa metacarpi* des *dritten* und *vierten* Fingers. 5. Ein besonderes Knöchelchen, frei liegend, mit dem *os hamatum* verbunden, kann als *hamus* desselben betrachtet werden ††. 6. Das *os capitatum* steht in Verbindung mit dem *os metacarpi* des *zweiten* Fingers ††." The nomenclature, which is taken from human anatomy, as well as the numbering of the fingers, proves that Mayer, like his predecessors, confounds the radial and the ulnar sides; in interpreting c_1 as "*hamus*," he seems to recognize the true volar side, but this it is difficult to reconcile with his principal error and with his interpretation of *s* as "*pisiforme*." The existence of the little carpal 3 is evidently not noticed by Mayer, so that his giving 6 as the number of carpalia is incorrect; in a later publication §§ he says, however, that in *Pipa* (*Asterodactylus*) "sechs oder sieben" carpalia are found.

* c_1 in my figs. 2 and 3.

† "Beiträge zu einer anatomischen Monographie der *Rana Pipa*," Nov. Act. Acad. C. L.-C. Nat. Cur. vol. xii. p. 2, 1825, p. 6 (532).

‡ $u+c_3$ in my figures. § c_4 . || $C+c_2$. ¶ *r*. ** *s*. †† c_1 .

†† Mayer's first, second, third, and fourth fingers are thus really the fifth, fourth, third, and second.

§§ 'Analecten für vergleichende Anatomie,' p. 34.

We come next to Brühl*, who in the tab. p. xxv, in fig. 11 A, represents the "Vorn- (Dorsal-) Sicht des linken Carpus und seiner Nachbartheile;" the carpal bones are tolerably well given, setting aside that the markings of the surfaces are rather indistinct; the radial and ulnar sides are rightly distinguished, and consequently also his numbering of the metacarpals and their carpals is correct †; but nevertheless Brühl commits an error, quite as grave as that of his predecessors, having confounded the dorsal and volar sides, and besides mistaking the right hand for the left! His figure really represents, as will immediately appear on comparing it with my figure 2, not the fore side of the left hand but the hind side of the right.

Exactly the same mistake is found in the latest publication on the carpus of the Anurans by G. B. Howes and W. Ridewood ‡, whose figure 1 on pl. vii. is supposed to represent the left hand from above of an adult *Pipa*, ♂, and fig. 2, the left hand of a very young specimen with the carpus not yet ossified, but in reality both show the right hand seen from the volar side. Hence these authors describe the sesamoid *s* as lying ventrally (*l. c.* p. 162), place the process *x* of the great ulnar carpale *u + c₅*, the "postaxial lobe" (* in their figure 1), behind the ulna, and find the coalesced bones of the forearm in a quite exceptional position, the outer edge of the ulna being "directed dorsally. As the result of this, the radius comes to lie in the plane of the extended hand, while the ulna lies above it." In reality the forearm is essentially in the same position as in other Anurans, *i. e.* when the plane of the carpus is directed from right to left, then the plane of the forearm is placed obliquely to the former, with the radial edge turned forwards and inwards, the ulnar edge backwards and outwards; only this torsion of the forearm is still more strongly marked than in other Anurans; and the carpus, moreover, forms an obtuse angle with the forearm, especially apparent when the arm is seen from the radial side (*cf.* fig. 3). Howes and Ridewood quote of previous authors Breyer, Meckel, and Mayer; but they seem not to have been aware of the mistakes of these authors, and give the two papers of Mayer as by two different authors. Of special interest is their observation that the bone *s* is wanting in a

* 'Zootomie aller Thierklassen,' Atlas, tab. p. xxv (1876).

† *c₁* of my figures is regarded by Brühl as not belonging to the carpus, and is named "radio-sesamoideum;" the sesamoid *s* he seems not to know at all.

‡ "On the Carpus and Tarsus of the Anura," Proc. Zool. Soc. 1888, p. 141.

young specimen of 19 millim. length, and thus its nature as a sesamoid seems to be proved; moreover, they have shown that the bony piece c_1 is preformed in cartilage like the true carpalia, and originally without connexion with metacarpale II; thus its interpretation as a true carpal bone would seem to be accepted by others besides "Daumen-Enthusiasten" (Brühl). The process α is said to be wanting.

That Brühl, Howes, and Ridewood, though they rightly distinguish the radial and ulnar sides, yet confound the dorsal and volar sides, seems to be explained by the singular form of the metacarpals (*cf.* below); the confounding of the right and left fore limbs is a mere consequence of the first error, and would be easily intelligible if the observers had only had to do with isolated limbs. This seems partly to have been the case with Howes and Ridewood, as they (*l. c.* p. 143) mention having received limbs of *Pipa* from Prof. Wiedersheim; but besides they have examined a large male and a complete young specimen, and this being the case I am not able to account for their mistake.

As to the question how the carpalia of *Pipa* are to be understood and named, we first meet with the difficulty that the interpretation of the anuran carpus is not at all universally settled, and secondly that *Pipa* in several points is somewhat exceptional.

Generally the proximal series of the anuran carpus consists of two bones, which Gegenbaur* regards as radiale and ulnare; in the distal series there may be one piece to each metacarpal, called by Gegenbaur carpalia 1-5, as in *Xenopus*, where all the bones are well developed (*cf.* figs. 5, 6, p. 205); but most frequently the number of these pieces is reduced through coalescence (e. g. in *Hyla*, *Rana*, *Bufo*, &c., the metacarpalia III-V being here carried by one carpale); and finally on the radial side there is generally interposed a larger piece, interpreted by Gegenbaur as a dislocated centrale; in some cases it extends upwards beside the radiale and joins the radius, so that it seems to belong to the upper series, which consequently would acquire the three pieces typical to most vertebrates; this junction with the radius, however, is of secondary nature and is wanting in younger stages, so that the proximal series really contains but two bones. Concerning the ulnar bone, all authors agree as to its corresponding to the ulnare; its constant position outside a branch of *arteria*

* Unters. zur vergl. Anat. des Wirbelthiere: "Carpus und Tarsus," 1864.

brachialis, as in Urodela and some Reptiles, puts the correctness of this view beyond doubt. As to the radial bone opinions differ: Gegenbaur supposes the intermedium to have disappeared, and regards it as the radiale, as already stated; on the other hand, it is interpreted by Born* as intermedium, and the centrale of Gegenbaur as radiale, partly because he thinks he has found another centrale in some *Alytes* and *Pelobates* larvæ, partly because the disputed centrale in some cases joins the radius. Howes and Ridewood, however, have confirmed (*l. c.* p. 159) that it does not originally belong to the proximal series, and besides made it less probable that any importance is to be ascribed to Born's centrale; they use the indifferent name *lunatum*, but state that this must be either radiale or radiale + intermedium; the centrale of Gegenbaur is named *naviculare* and regarded as a *radial* centrale. Emery † thinks that the proximal-radial bone is the coalesced radiale and centrale, and that Gegenbaur's centrale belongs to the distal series as a "carpale præpollicis," because he thinks he has found in a *Pelobates* larva a trace of a sixth finger on the ulnar side, whence that finger, which generally is regarded as the first, in his opinion becomes a "præpollex;" the second to fifth fingers are reckoned as first to fourth. Moreover, Emery finds in a group of closer-set cellules in the tissue between the cartilaginous ulnare and radiale in larvæ of *Rana esculenta* "ein nicht mehr verkörperlendes Intermediumrudiment."

In opposition to Emery, however, I may say that in the larval hands of *Bombinator* and *Rana platyrhinus*, which I have examined, partly through section-cutting, partly in clove-oil, I have not been able to find any trace of a finger on the ulnar side of that which I, in accordance with most authors, have named the fifth, nor have I seen anything like a rudiment of an intermedium; moreover, I feel convinced that Emery has misinterpreted the preparation on which his fig. 1 (*l. c.* p. 285) is founded: *s* is not "scaphoideum (carpale præpollicis)," but either carpale 2 or carpale 1; *ce* is scaphoideum (auth.), *i. e.* centrale of Gegenbaur, which does not at all coalesce with *r* (radiale), but in later stages appears on the lateral border of the carpus.

As to the interpretation of the *distal* series of the anuran carpus, I may add that Howes and Ridewood do not admit

* "Nachträge zu 'Carpus und Tarsus,'" *Morphol. Jahrb.* 6 Bd. 1880, p. 61.

† "Zur Morphologie des Hand- und Fuss skeletts," *Anat. Anz.* 5 Jhg. 1890, p. 283.

that the bone which carries metacarpale V is carpale 5, because they have found in a single species (*Xenophrys*) a small cartilage (said even to ossify in old specimens) in the ligament which extends from carpale 4 to metacarpale V, also seen in *Bombinator* and *Discoglossus*, which cartilage (or ligament) they regard as the true carpale 5, while they interpret the latter bone as an ulnar centrale; thus the hand would possess two centralia, both dislocated towards their respective sides of the hand. In a *Bombinator*-larva having the fore limbs yet included in the gill-cavity, but the outer side of the forearm and the two outer fingers coloured, I have not found any trace of this ligament, and it seems to me very improbable that two centralia should be greatly developed and still both lie out of their primitive position. On the whole, I am unable to admit that the later investigations have made it necessary to give up the interpretation due to Gegenbaur; therefore I have followed him, and I have named the carpal bones in *Xenopus* (cf. figs. 5, 6, p. 205) in accordance with his views. Now, in comparing *Pipa* with the latter, the reductions met with in *Pipa* will be easily explained. It is thus quite certain that the great ulnar bone in *Pipa* consists of the coalesced ulnare and carpale 5, for in *Xenopus* we recognize the process x on the ulnare, and the process y on carpale 5; besides, the above-mentioned artery, which in *Xenopus* is seen at a , runs in *Pipa* in a groove under a projection of the great ulnar carpale, carrying the articular face for the radius, and mesially to this artery we find the two articular faces where the pieces r and $C+c_2$ join, but in *Xenopus* r and C articulate with c_5 . Hence it follows that r in both genera is the same bone, radiale. The bone in *Pipa* which carries metacarpale II is in all probability the coalesced centrale and carpale 2; closer examination will show a trace of a process answering to the large process on C in *Xenopus*, and this being the case the bone in question contains at any rate the centrale, and I see no reason why the carpale 2 should have quite disappeared.

Howes and Ridewood have also interpreted the just-mentioned bones in a similar manner; whereas Brühl, without further ceremony, designates the bone $C+c_2$ as the carpale 2, making no remarks as to the absence of our centrale (Endodiocarpale or Endo-radiocarpale of Brühl).

The *metacarpals* in *Pipa* do not seem to have attracted the special attention of previous authors, probably because their form apparently corresponds very well with the supposed volar face, but undoubtedly the mistakes are mainly due to the singular form of these bones. Metacarpale II is

curved a little inward (radially), and besides at its base feebly convex towards the back of the hand; that is to say, it is not unlike the corresponding bone in *Rana*, except in its long and slender form. A similar form is possessed by the outer metacarpal, Me. V, only it is curved towards the ulnar side; on the contrary, metacarpale III and metac. IV, although at their bases a little concave on the underside, are rather strongly curved, with the *convexity towards the palmar side*; so that the whole hand seems to have the back concave and the palm convex. As the bases of metacarpale II and metac. V project over the level of the two middle metacarpals, the two outer fingers can be turned inwards over the middle fingers; and such being the case, the hand seems still narrower and its back looks still more concave. All the metacarpals are long and slender; the two middle ones are about equal in length, but are somewhat longer than the outer, which are also nearly of equal length. Of the fingers the innermost (II) is shortest, the penultimate (IV) longest; next comes the third (III), and last the outer (V); the number of the phalanges is 2, 2, 3, 3 (counting from the radial side), as typical in Anurans.

That the earlier authors gave wrong descriptions of the fingers was due to the mistakes above mentioned. Thus Schneider says (*l. c.* p. 262):—" *Externi* digiti articulos 2, ante penultimi itidem 2 ut tertii, *intimi* 3 numeravi, quibus adheret pars extrema aculeata. Sed pedum anteriorum articulos extremos agnoscere accurate non licuit, præfractis plerisque mucronibus." The figure shows the fingers incorrectly and does not agree with the text. Breyer only refers to his figures, of which that on tab. i. represents three phalanges in all the fingers and the shortest finger towards the outer side; that on tab. ii. gives the correct number, but the hand, as stated above, is turned so that the inner finger comes to lie on the outer side. Meckel (*l. c.* p. 466) says concerning the Anurans:—" Der zweite und dritte Finger haben im allgemeinen zwei, die beiden äusseren drei Glieder. Doch hat *Pipa* an den drei inneren drei, am *äussersten* nur zwei." And later on: " Im allgemeinen ist der zweite vollkommene Finger (eigentlich also der dritte) der bei weitem kürzeste, der darauf nach aussen folgende der längste: bei *Pipa* dagegen ist der *zweite* der längste." Mayer makes no remarks about the fingers; but in the work of Duméril and Bibron* (who do not go into the osteology of the hand) we read:—" Le *second*

* 'Erpétologie générale,' t. viii. p. 775.

doigt est le plus long des quatre, après lui c'est le troisième, ensuite le premier, puis le *dernier*, qui est par conséquent le plus court." Thus here also we meet with the common mistake.

Of the old authors Bonnet* *perhaps* observed the correct numbering of the fingers; he says ". . . leur longueur étoit inégale. Le *troisième* qui étoit le plus long . . . ;" but whether he really had a clear idea of the hand cannot be decided either from his text or figures.

If we now make an examination of the exterior of the hand we shall observe the following facts: the back of the hand is concave, the palm convex, and the outer fingers can be turned inwards over the middle ones, so that the hand acquires the peculiar narrow form which is often seen in specimens preserved in spirit and which certainly will be found in the living animal. The distribution of colour that in Anurans usually very distinctly characterizes the lower and upper sides is here but feebly marked; yet I have found among the specimens which I had the opportunity of examining a few in which the colour was paler and spotted, like the belly, on the inner side of the arm as well as on the upper side of the wrist and the three inner metacarpals; besides, the skin on the back of the hand is often somewhat smoother and finer than on the palm. That a hand like this is used very little for walking seems evident; the absence of tubercles from the palm points in the same direction. Unfortunately we know nothing as to the mode of locomotion in the genus *Pipa*, our information concerning the habits of this animal being very scanty; the old and hitherto (as far as I know) the only observers of the animal in the living state (Miss Merian and Dr. Fermin) merely noticed its singular mode of breeding. Probably *Pipa* will be found essentially aquatic in its habits. Miss Merian † only says that it dwells on a plant growing in the water. Fermin ‡ states that it lives in the swamps of the thick forests, and that the specimens he kept were almost constantly swimming about, and scarcely ever sat quietly at the bottom.

* "Observations sur le *Pipa* ou Crapaud de Surinam," Journal de Physique, t. xiv. 1779, p. 427.

† 'De generatione et metamorphosis insectorum Surinamensium,' Amstelod., 1710, p. 70.

‡ 'Abhandlungen von der Surinamischen Kröte &c.,' übersetzt v. Goeze. Braunschweig, 1776.

XENOPUS.

The structure of the hand in this genus is mentioned by but few authors. Mayer ("Analekten," 1835, p. 34) simply says about *X. levis* (Daud.) "Der Carpus besteht aus fünf bis sechs kleinen Knöchelchen," and makes no remarks concerning the skeleton of the fingers. The accompanying figure of the whole skeleton in his work (which is with some additions due to Schlegel) is rather incorrect both as regards the carpus and the fingers, the latter being assigned the following number of joints, 2, 3, 3, 2. From the relative length of the fingers and from the description of the exterior of the animal (*cf. l. c.* tab. ii. fig. v.) it is evident that the hand is turned with the inner side outwards and the palm looking upwards. Mayer says (*l. c.* p. 29), "Es sind vier Finger vorhanden, wovon der *zweite innere* um eine halbe Linie länger ist als die übrigen;" in reality this applies to the penultimate finger. Hallowell*, in his description of *Xenopus* (*Dactylethra*) *Mülleri*, Peters, says, "... fourth finger stoutest, *second longest*, first and fourth of nearly equal length;" thus he falls into the same error as Mayer. A. Duméril† figures the hand correctly in *X. calcaratus*, Peters; but as the text is no improvement on Hallowell's description of the fingers in *X. Mülleri*, with which Duméril holds his species to be identical, the correctness of the figure is apparently due to the artist. Peters‡, in his diagnosis of the genus *Xenopus*, rightly observes "Die Zahl der Phalangen der Finger 2, 2, 3, 3 und der Zehen 2, 2, 3, 4, 3 ist die gewöhnliche;" but in the beautiful pictures of his *X. Mülleri* (*l. c.* tab. xxv.) he still depicts the lower side of the hand in that figure which represents the animal seen from above (fig. 3), and the upper side of the hand in fig. 3 a, representing the lower side of the animal. Howes and Ridewood (*l. c.* p. 163, pl. vii. fig. 4) have given the first and hitherto only complete representation of the carpus (*X. levis*); but they have here made the same mistake as in *Pipa*, figuring the right hand from behind, while they believe they have represented the left hand from the dorsal side. This is especially evident from their referring to "the great expansion of the head of the fourth metacarpal," a peculiar feature

* "Notice of a Collection of Reptiles from the Gaboon Country, West Africa," Proc. Acad. Nat. Sci. Philad. 1857, t. ix. p. 65.

† "Reptiles et Poissons de l'Afrique occidentale," Arch. du Muséum d'Hist. nat. t. x. 1858-61, p. 231.

‡ "Reise nach Mossambique," Zool. iii. Amphibien, 1882, p. 180.

which cannot be seen from the dorsal side of the hand, on account of the outer metacarpals lying at a higher level than the middle ones, and thus being able to move inwards over the middle fingers, as in *Pipa*: moreover these authors must have regarded the sesamoid bone (represented in dotted lines *l. c.* fig. 4) as ventral in *Xenopus* as well as in *Pipa*, otherwise they would have pointed out its different position; in the skeleton which I have examined it touches the radius only, while Howes and Ridewood have found it lying in the line of junction between the ulna and radius.

Owing to this error in confusing the ventral and dorsal sides of the hand in *Xenopus*, and as the figure of Howes and Ridewood does not depict the surface of the carpal bones, though it is of some value for comparison with *Pipa*, I have thought it best to give fresh figures without entering into further details as to the single bones.

Fig. 5.

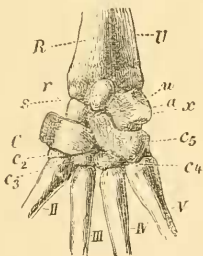
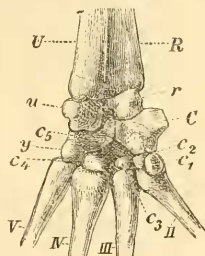


Fig. 6.



Left hand of *Xenopus levis* (Daud.). Fig. 5 seen from the dorsal side, fig. 6 from the volar side. R, radius; U, ulna; r, radiale; u, ulnare; C, centrale; c_1 - c_5 , carpalia 1-5; II-V, metacarpalia II-V; s, sesamoid bone.

The *metacarpals* and the *fingers* are very slender; the metacarpals, of which the middle ones are the longest, are neither so long nor aberrantly curved as in *Pipa*: of the fingers the penultimate (IV) is the longest, next comes the outer (V), then the third (III), and the innermost (II) is shortest; but the difference in length is rather small, so that at a first glance they seem almost equal. In most Anurans the distribution of the colour on the fore limbs is very characteristic, the side looking towards the body being pale, as is the back of the hand, except the two outer fingers (IV, V), which are coloured; the same condition is partly seen in *Xenopus*, especially in *X. levis*, where I have found the back

of the hand pale except the outer finger, while the lower side of the hand has the colour of the outer side of the arm. Boulenger* seems to be the only author who has hitherto understood the hand in this animal correctly, having had the opportunity of observing it in the living state; he has noticed the position of the hand with the fingers superposed, the inner fingers only touching the ground, and the colourless condition of the inner (*i. e.* upper) side, though he has not remarked that in the latter respect this frog resembles most others. A most interesting addition to the brief biological account given by Boulenger we owe to Leslie †, who states that *X. levis* is essentially aquatic in its habits, that it, unlike other frogs, feeds only in the water and forces its prey into its mouth by means of its hands, which act as a pair of clasps ‡; its mode of locomotion on land is by difficult and awkward crawling and leaping, and when at rest it never assumes a sitting posture, and the back never appears humped. Even Leslie has made a slight mistake, saying that in the breeding male “the *palmar* surface and inner side of the forearm acquire a black horny layer;” this structure is found on the *back* of the hand, as is the case with our frogs and toads.

XXIV.—*On the Arrangement and Inter-relations of the Classes of the Echinodermata.* By Prof. F. JEFFREY BELL, M.A.

HAVING recently had to attempt the formulation of exact diagnoses of the various living classes of the Echinodermata, I have been led to consider closely the claims of the present current classification into Pelmatozoa and Echinozoa. The moment we look at the matter from the phylogenetic point of view we find ourselves involved in a very maze of difficulties. Are the stalked derived from the unstalked forms or *vice versa*? If the group Echinozoa is natural, how intimate are the relations of the Holothurians to the other skeleton-bearing forms with remnants at least of a calycinal area? What are the points, other than the non-fixed condition, which unite

* Proc. Zool. Soc. Lond. 1887, p. 563.

† “Notes on the Habits and Oviposition of *Xenopus levis*,” Proc. Zool. Soc. Lond. 1890, p. 69.

‡ Perhaps the great process on the centrale, the process *x*, &c. are connected with this peculiar use of the hands; and it is probable that we shall some day learn that *Pipa* behaves in a similar way.